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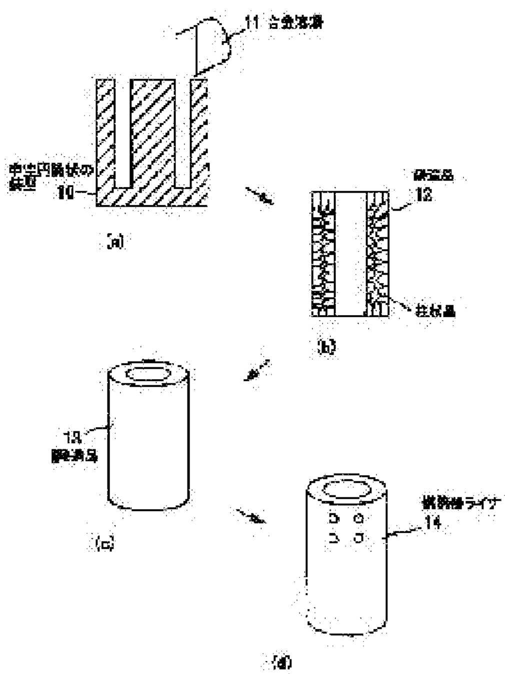
(54) COMBUSTOR LINER FOR GAS TURBINE, AND ITS PRODUCTION



(57)Abstract:
PROBLEM TO BE SOLVED: To provide a combustor liner for gas turbine, superior in high temperature strength to a combustor liner made of conventional refined and cast alloy and hardly causing structural change attendant on aging, and its production, by applying casting treatment and then applying hot plastic working such as forging treatment.
SOLUTION: A combustor liner 14 for gas turbine has a composition consisting of, by weight, 18.0-25.0% Cr, 17.0-23.0% Co, ≤10.0% of at least either of Mo and W, 0.01-3.0% Al, ≤2.0% Ti, ≤2.0% Ta, ≤2.0% Nb, ≤0.5% Hf, ≤0.5% C, and the balance Ni with inevitable impurities.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention is the art about a flame tube of the bell shape which forms the combustion chamber of a gas turbine combustion device, and a manufacturing method for the same, is excellent in high temperature strength, and relates to the gas turbine combustion device liner which the organization change accompanying prescription does not produce easily, and its manufacturing method.
[0002]
[Description of the Prior Art]As for the gas turbine for power generation, the research and development to efficient-izing of a gas turbine from a point of effective use of an energy resource are done positively. Since generation efficiency of a gas turbine improves so that combustor outlet gas temperature is high, the temperature rise of gas turbine inlet temperature is promoted. However, for the charge of hot-parts material which constitutes a gas turbine, it is a harsh environment extremely, and hot strength reduction, and remarkable high temperature corrosion and high temperature oxidation pose a problem.
[0003]In the conventional 1100-1300 ** class gas turbine, flame-tube substrate temperature had become about 550-650 **. A temperature rise progresses further, and is predicted that flame-tube substrate temperature amounts to about 850-950 ** by the 1500 ** super-class gas turbine in the future, and the material which has the heat resistance in 850-950 ** is called for as a flame-tube material.
[0004]HS188 etc. which uses as the main ingredients Hastelloy-X which is rolled stock and uses a Ni group as the main ingredients as a conventional charge of flame-tube material, and a Co group has been applied. However, high temperature strength [in / with these rolling materials / an 850-950 ** high temperature region] was low, and the application as a prospective flame-tube material was dramatically difficult.
[0005]On the other hand, although the above-mentioned rolling material is excelled in heat resistance by adding aluminum and Ti with the precipitation-strengthening type precision casting alloy by the deposit of gamma' phases, such as $nickel_3$ (aluminum, Ti), Flame-tube-shaped processing and weldbonding were difficult and the application to a flame tube was difficult.

[0006]Then, for example, the method of manufacturing a flame tube using a casting process is proposed as published by JP,9-78205,A etc.
[0007]Drawing 19 is a figure showing the manufacturing method of the flame tube by a conventional method.
[0008]As shown in drawing 19 (a), the molten metal 2 which uses a Ni group or a Co group as the main ingredients is first cast to the rotating bell-shaped mold 1, and the cast 3 of the flame-tube shape shown in drawing 19 (b) is produced. Then, as shown in drawing 19 (c), finishing by machining is performed to the cast 3, and the flame tube 4 made from a precision casting alloy is produced.
[0009]By the above-mentioned method, although excelled in heat resistance, processing to liner shape became applicable [the difficult precision casting alloy], and the manufacture of the flame tube excellent in heat resistance of it was attained.
[0010]
[Problem(s) to be Solved by the Invention]However, the flame tube 4 manufactured by the manufacturing method of the conventional flame tube shown in drawing 19 has in addition low high temperature strength, and it is clear that its the organization change accompanying prescription takes place easily.
[0011]First, in the liner 4 made from a precision casting alloy, since cooling rates differed, and the grain structure became uneven, intensity had shown dispersion in the wall side in the bell-shaped mold 1, and the central part.
[0012]Drawing 20 is a figure showing the alloy structure after the precision casting manufactured according to the casting process.
[0013]As shown in drawing 20, since the crystal grain 5 becomes large easily at the time of coagulation, sufficient high temperature strength is not obtained by a casting process. $M_{23}C_6$ type carbide 6 (M) which plays the role of precipitation strengthening [Cr and] Since Mo or W deposits in a grain boundary, and MC type carbide 7 (M is Ti, Nb, or Ta) deposits in the inside of a grain, and a grain boundary and it is easy to make these carbide big and rough at the time of coagulation, high temperature strength sufficient with the precision casting alloy by a casting process cannot be obtained.
[0014]Drawing 21 is a figure showing the organization after heating a precision casting alloy at 850 ** for 100 hours.
[0015]As shown in drawing 21, it is clear to the organization of the precision casting alloy after heating that the linear embrittlement phase (TCP phase) 8 which was not seen before heating appears near the grain boundary. Since these embrittlement phases 8 serve as a starting point of a crack easily while causing a ductility fall, they become a major factor which causes strength reduction.
[0016]The purpose of this invention is as follows.
By being made in order to cope with such a technical problem, and performing plastic working between heat, such as forging treatment, after performing casting processing, By distributing homogeneity and the carbide which carries out minuteness making and deposits in the inside of a crystal grain, and the grain boundary for the grain structure, prevent the appearance of an embrittlement phase and excel the conventional flame tube in high temperature strength.
Provide a flame tube for gas turbines which the organization change accompanying prescription does not produce easily, and a manufacturing method for the same.

[0017]
[Means for Solving the Problem]The flame tube for gas turbines according to claim 1, By weight %, Cr:18.0-25.0%, Co:17.0-23.0%, Mo and : [at least one sort of] 10.0% or less of W, aluminum:0.01-3.0%, less than Ti:2.0%, less than Ta:2.0%, less than Nb:2.0%, Hf: Contain 0.5% or less and C:0.5% or less of element, and the remainder comprises a Ni group and inevitable impurities.
[0018]In this invention, a reason which limits a composition range of a gas turbine combustion device liner is explained for every element. Especially % that expresses a presentation in the following explanation is taken as weight %, unless it refuses.
[0019]Cr (chromium) is an element indispensable to raise oxidation resistance and corrosion resistance. In this invention, although content of Cr was specified as 18.0 to 25.0%, when high temperature corrosion resistance with the content sufficient at less than 18.0% cannot be secured and content exceeds 25.0%, it is for ductility and toughness to deteriorate.
[0020]Co (cobalt) is an element provided also with the characteristic which raises high temperature corrosion resistance while contributing to solid solution strengthening. Although content of Co was specified as 17.0 to 23.0%, when high temperature corrosion resistance with the content sufficient at less than 17.0% cannot be secured and content exceeds 23.0%, it is for high temperature strength to fall.
[0021]W (tungsten) is a very effective element as a solid-solution-strengthening element. In this invention, although content of W was specified as 10.0% or less, when content of W is increased, it is for toughness and a heating embrittlement characteristic to fall remarkably. since the effect same also about Mo (molybdenum) as W is acquired, it is good also considering content as 10% or less to unite both 10.0% or less, or W and Mo for Mo instead of W.
[0022]aluminum (aluminum) and Ti (titanium) are elements very effective in improvement in intensity as a gamma' phase formation element. However, since gamma' phase is not formed when aluminum does not contain, 0.01% or more is required for content of aluminum. Content of aluminum was specified, and when content of aluminum and Ti was increased, since weldability fell, in this invention, a Ti content was specified as 2.0% or less 0.01 to 3.0%.
[0023]Ta (tantalum) and Nb (niobium) are the very effective elements as a solid-solution-strengthening element. However, when content of Ta exceeded 2.0%, since toughness and a heating embrittlement characteristic fell remarkably, content of Ta was specified as 2.0% or less. When content of Nb exceeded 2.0%, since oxidation resistance deteriorated remarkably, content of Nb was specified as 2.0% or less.
[0024]Hf (hafnium) is an element which has the characteristic which raises structural stability and oxidation resistance for a long time. In this invention, although content of Hf was specified as 0.5% or less, when the content exceeds 0.5%, it is because solution treatment of an alloy becomes difficult.
[0025]C (carbon) is an element which plays a role which stabilizes an organization while being a crystal-stressing element. Although content of C was specified as 0.5% or less, when content of C exceeds 0.5%, it is for toughness and processability to deteriorate remarkably.
[0026]The flame tube for gas turbines according to claim 2, By weight %, Cr:15.0-35.0%, nickel:5.0-30.0%, and W:20.0% or less, less than Ta:5.0%, less than Ti:2.0%, and

C:1.0% or less of element are contained, and the remainder comprises a Co group and inevitable impurities.
[0027]In this invention, a reason which limits a composition range of a gas turbine combustion device liner is explained for every element. Especially % to which the following explanation smells also express a presentation is taken as weight %, unless it refuses.
[0028]Cr is an element indispensable to raise oxidation resistance and corrosion resistance. In this invention, although content of Cr was specified as 18.0 to 25.0%, high temperature corrosion resistance with content of Cr sufficient at less than 18.0% is not securable. It is for ductility and toughness to deteriorate on the other hand, if content exceeds 25.0%.
[0029]nickel (nickel) is an element indispensable to stabilize a matrix. Although content of nickel was specified as 5.0 to 30.0%, when effect with the content sufficient at less than 5.0% cannot be expected but content of nickel exceeds 30.0% on the other hand, it is for high temperature strength and corrosion resistance to fall remarkably.
[0030]W, Ti, and Ta are elements effective in improvement in intensity as a carbide formation element. Although content of W was specified as 20.0% or less, when content of W is increased, it is for toughness to fall remarkably. When content of Ti and Ta was increased, since weldability fell, content of 5.0% or less and Ti was specified for content of Ta as 2.0% or less.
[0031]C is an element which plays a role which stabilizes an organization while being a crystal-stressing element. In this invention, although content of C was specified as 1.0% or less, when content of C exceeds 1.0%, it is for toughness and processability to deteriorate remarkably.
[0032]A manufacturing method of the flame tube for gas turbines according to claim 3, In a manufacturing method of a cylindrical flame tube which forms a combustion chamber of a gas turbine combustion device, After ingoting a steel ingot cylindrical according to a casting process using a charge of an alloy which uses either a Ni group or a Co group as the main ingredients, cast structure which performed plastic working between heat to said ingot articles, and was generated in said ingot articles is destroyed.
[0033]destroying a big and rough columnar crystal by which it was generated after casting processing by performing plastic working between heat after casting processing in this invention -- a crystal grain -- homogeneity -- and minuteness making can be carried out. While it is possible to distribute carbide which deposits in the inside of a crystal grain and a grain boundary and excelling in high temperature strength by forging treatment, a flame tube which organization change accompanying prescription does not produce easily can be obtained.
[0034]A manufacturing method of the flame tube for gas turbines according to claim 4 ingots a bell-shaped steel ingot in a manufacturing method of the flame tube for gas turbines according to claim 3, using a centrifugal casting process as a casting process.
[0035]In this invention, by using a centrifugal casting process which pours molten metal into a mold which carries out a high velocity revolution, and it is made to solidify as a casting process, there are comparatively few alloy segregations in a stage of a cast, and effects, such as improving strength, can be further acquired by performing forging treatment after that.
[0036]A manufacturing method of the flame tube for gas turbines according to claim 5

performs forging treatment as plastic working between heat in a flame tube for gas turbines given in claims 3 and 4.
[0037]By using a forging treatment method which carries out plastic deformation of the metal and fabricates it in this invention, using compressive force, after heat-treating in an 800-1200 ** temperature requirement, While it is possible to distribute homogeneity and carbide which can carry out minuteness making and deposits in the inside of a crystal grain and a grain boundary and excelling a crystal grain in high temperature strength, a flame tube which organization change accompanying prescription does not produce easily can be obtained.
[0038]A manufacturing method of the flame tube for gas turbines according to claim 6, In a manufacturing method of a flame tube for gas turbines given in either to claims 3-5, according to a casting process, after ingoting a bell-shaped steel ingot smaller than a actual diameter of a liner, forging treatment accompanied by expansion is performed as plastic working between heat.
[0039]In this invention, in a casting process, since a bell-shaped steel ingot smaller than a actual diameter of a liner is ingoted, it is possible to reduce a manufacturing cost of casting from a mold being small and ending.
[0040]A manufacturing method of the flame tube for gas turbines according to claim 7, In a manufacturing method of the flame tube for gas turbines according to claim 4, after ingoting a steel ingot cylindrical according to a casting process, while processing said ingot articles tubular with extrusion, forging treatment is performed as plastic working between heat.
[0041]In this invention, since a hollow type mold is not needed but a cylinder mold which is simple shape can be applied by using extrusion, it is possible to reduce a manufacturing cost of a mold.
[0042]A manufacturing method of the flame tube for gas turbines according to claim 8, In a method of manufacturing a flame tube for gas turbines which is a manufacturing method of a flame tube for gas turbines given in either to claims 3-7, and has the alloy composition according to claim 1, After performing forging treatment to ingot articles, solution treatment is performed in 1000-1300 ** for 1 to 10 hours, and aging treatment is further performed in 800-950 ** after quenching for 1 to 12 hours.
[0043]In this invention, in the case of an alloy which uses a Ni group as the main ingredients, while excelling in high temperature strength by performing aging treatment further after solution treatment, a flame tube which organization change accompanying prescription does not produce easily can be obtained.
[0044]A manufacturing method of the flame tube for gas turbines according to claim 9, In a method of manufacturing a flame tube for gas turbines which is a manufacturing method of a flame tube for gas turbines given in either to claims 3-7, and has the alloy composition according to claim 2, After performing forging treatment to ingot articles, solution treatment is performed in 1000-1300 ** for 1 to 10 hours.
[0045]In this invention, in the case of an alloy which uses a Co group as the main ingredients, while excelling in high temperature strength by performing solution treatment, a flame tube which organization change accompanying prescription does not produce easily can be obtained.
[0046]
[Embodiment of the Invention]Hereafter, the embodiment of a flame tube for gas turbines

concerning this invention and a manufacturing method for the same is described with an example and a comparative example.
[0047]In the 1st embodiment (Examples 1-2, comparative example 1-2, conventional example 1-2; drawing 1 - 9; Tables 1-3) book embodiment, it checked having the structural stability after the high temperature strength excellent in the flame tube manufactured using forging treatment as plastic working between heat, and aging treatment.
[0048]Drawing 1 is a process figure showing the manufacturing method of a flame tube.
[0049]As shown in drawing 1 (a), first, the molten metal 11 (charge of an alloy which uses a Ni group or a Co group as the main ingredients) was cast to the bell-shaped mold 10, and the cast 12 of the flame-tube shape shown in drawing 1 (b) was produced. After heat-treating the cast 12 at 800-1200 ** and inserting the mandrel (not shown) of metallic mold metallurgy, forging treatment shown in drawing 1 (c) was carried out by applying compressive force with a high voltage pressing machine. This destroyed the cast structure generated in the casting stage, and the forging 13 without cast structure was produced. Then, as shown in drawing 1 (d), finishing by machining was performed and the flame tube 14 was formed.
[0050]In this embodiment, in order to verify the characteristic of the flame tube 14 produced by doing in this way, texture observation, the elevated temperature tensile test, and the prescription examination were done using the specimen of Examples 1-2 and the comparative examples 1-2 which are shown below, and the conventional examples 1-2.
[0051]In example 1 (Table 1; sample No.1) this example, it has a chemical composition ingredient shown in sample No.1 of Table 1, and the charge of an alloy which uses a Ni group as the main ingredients was used. Specifically, the remainder was used as nickel and inevitable impurities including Cr:22.5%, Co:19.0%, W:2.0%, aluminum:1.9%, Ti:1.0%, Ta:1.0%, Nb:0.8%, C:0.1%, and Hf:0.15%.
[0052]
[Table 1]

	試料 No.	化学組成 (wt%)											
		Cr	Co	W	Al	Ti	Ta	Nb	Fe	Mo	C	Hf	Ni
実施例1	1(Ni基)	22.5	19.0	2.0	1.9	1.0	1.0	0.8	–	–	0.1	0.15	bal.
実施例2	2(Co基)	23.5	bal.	7.0	–	0.2	3.5	–	–	–	0.6	–	10.0
比較例1	3(Ni基)	22.5	19.0	2.0	1.9	1.0	1.0	0.8	–	–	0.1	0.15	bal.
比較例2	4(Co基)	23.5	bal.	7.0	–	0.2	3.5	–	–	–	0.6	–	10.0
従来例	5(Hastelloy−X)	22.0	8.0	0.6	–	–	–	–	18.5	–	–	–	bal.
	6(HS188)	22.0	bal.	14.0	–	–	–	–	3.0	9.0	0.1	–	22.0

[0053]Forging treatment was performed, after casting in the charge of an alloy which has the above-mentioned presentation and obtaining a steel ingot. What performed solution treatment at 1150 ** after forging treatment for 4 hours, and performed aging treatment at 802 more ** for 8 hours was made into the sample board.
[0054]In example 2 (Table 1; sample No.2) this example, it has a chemical composition ingredient shown in sample No.2 of Table 1, and the charge of an alloy which uses a Co group as the main ingredients was used. Specifically, the remainder was used as Co and inevitable impurities including Cr:23.5%, nickel:10.0%, W:7.0%, Ti:0.2%, Ta:3.5%, and C:0.6%.
[0055]Forging treatment was performed, after casting in the charge of an alloy which has the above-mentioned presentation and obtaining a steel ingot. What performed solution treatment at 1175 ** for 1 hour was made into the sample board after forging treatment.

[0056]In the comparative example 1 (Table 1; sample No.3) book comparative example, it has a chemical composition ingredient shown in sample No.3 of Table 1, and the charge of an alloy which uses a Ni group as the main ingredients was used. Specifically, the charge of an alloy which has the same chemical composition range as sample No.1 of Example 1 was used.
[0057]After casting in the sample which has the above-mentioned presentation and obtaining a steel ingot, what performed solution treatment at 1150 ** for 4 hours, and performed aging treatment at 802 more ** for 8 hours was made into the sample board.
[0058]In the comparative example 2 (Table 1; sample No.4) book comparative example, it has a chemical composition ingredient shown in sample No.4 of Table 1, and the charge of an alloy which uses a Co group as the main ingredients was used. Specifically, the charge of an alloy which has the same chemical composition range as sample No.2 of Example 2 was used.
[0059]After casting in the charge of an alloy which has the above-mentioned presentation and obtaining a steel ingot, what performed solution treatment at 1175 ** for 1 hour was made into the sample board.
[0060]In the conventional example 1 (Table 1; sample No.5) book conventional example, the charge of an alloy which has a chemical composition ingredient with an application track record shown in sample No.5 (Hastelloy-X) of Table 1 was used as flame-tube material until now.
[0061]Specifically, sample No.5 used the remainder as nickel and inevitable impurities including Cr:22.0%, Co:8.0%, W:0.6%, and Fe:18.5%.
[0062]In the conventional example 2 (Table 1; sample No.6) book conventional example, the charge of an alloy which has a chemical composition ingredient with an application track record shown in sample No.6 (HS188) of Table 1 was used as flame-tube material until now.
[0063]Specifically, sample No.6 used the remainder as Co and inevitable impurities including Cr:22.0%, W:14.0%, Fe:3.0%, Mo:9.0%, C:0.1%, and nickel:22.0%.
[0064]In order to investigate the homogeneity of a crystal grain first, texture observation was performed about the flame-tube-like alloy.
[0065]Drawing 2 is a figure showing the texture observation result of the alloy of the flame tube which performed and manufactured forging treatment to the steel ingot after casting using the charge of an alloy shown in sample No.1 in Example 1.
[0066]As shown in drawing 2, the crystal grain 15 after the forge obtained from sample No.1 was a detailed organization in homaxial.
[0067]Drawing 3 is a sectional view showing the texture observation result of the alloy of the flame tube manufactured according to the casting process using the charge of an alloy of sample No.3 shown in Table 1 in the comparative example 1.
[0068]As shown in drawing 3, near the wall side of the bell-shaped mold 10, it became the big and rough columnar crystal 16, and had become the equiaxed grain 17 from cooling rates differing the wall side of the bell-shaped mold 10 in the central part in the alloy after casting obtained from the comparative example in the central part. This to the grain structure was very uneven.
[0069]Next, about the alloy obtained by Example 1 and the comparative example 1 which use a Ni group as the main ingredients, in order to investigate the influence of the intensity on the grain structure, the elevated temperature tensile test by the difference in

the extraction position of a specimen was carried out.
[0070]About sample No.1 of Example 1, the test piece for tensile test was extracted in the edge part and the central part near the mold wall side, and the test piece for tensile test was similarly extracted [3 / of the comparative example 1 / sample No.] in the edge part and the central part near the mold wall side. About these specimens, the elevated temperature tensile test (test temperature: 850 **) was carried out, and proof stress (YS), the maximum tensile stress (UTS), elongation, and a diaphragm were measured 0.2%. The result is shown in Table 2.
[0071]
[Table 2]

	試料	引張試験結果			
		YS (MPa)	UTS (MPa)	伸び (%)	絞り (%)
実施例1	周縁部 (No.1)	400	450	20	40
	中心部 (No.1)	398	448	20	39
比較例1	周縁部 (No.3)	290	310	29	51
	中心部 (No.3)	345	378	25	45
従来例	Hastelloy-X	200	275	50	70
	HS188	270	350	92	80

[0072]The measurement result of the 0.2% proof stress (YS) about Example 1 in Table 2 and the comparative example 1 and the maximum tensile stress (UTS) is shown in the graph of drawing 4.
[0073]As shown in drawing 4, in sample No.3 of the comparative example 1, it was checked by the difference from the edge part and the central part which are the extraction positions of a specimen as a result of the elevated temperature tensile test that intensity has dispersion. In sample No.1 of Example 1, it became clear that there was no dispersion in the intensity by the difference from the edge part and the central part which are the extraction positions of a specimen.
[0074]Next, the elevated temperature tensile test was further carried out about the alloy of Example 1 and the comparative example 1 which use a Ni group as the main ingredients, and the alloy obtained by the conventional example.
[0075]About sample No.1 of Example 1, the test piece for tensile test was extracted in near a center, and, specifically, the test piece for tensile test was extracted [3 / of the comparative example 1 / sample No.] in near a center in a similar manner. The specimen was extracted about HS188 in Hastelloy-X [in sample No.5 of a conventional example], and sample No.6. About these specimens, the elevated temperature tensile test (test temperature: 850 **) was carried out, and proof stress (YS), the maximum tensile stress (UTS), elongation, and a diaphragm were measured 0.2%. The result is shown in Table 2 and drawing 5.
[0076]As shown in Table 2 and drawing 5, as a result of the elevated temperature tensile test, sample No.1 of Example 1 had the most outstanding 0.2% proof stress and the maximum tensile stress, and, subsequently it was the order of sample No.3 of the comparative example 1, and HS188 of a conventional example. Therefore, having the outstanding high temperature strength was checked by performing forging treatment to the alloy which uses a Ni group as the main ingredients.
[0077]On the other hand, the elevated temperature tensile test and the oxidation-resistant examination were done also with the alloy which uses a Co group as the main ingredients.
[0078]About sample No.2 of Example 2, the test piece for tensile test was extracted in

near a center, and, specifically, the test piece for tensile test was extracted [4 / of the comparative example 2 / sample No.] in near a center in a similar manner. About these specimens, the elevated temperature tensile test (test temperature: 850 **) was carried out, and proof stress (YS), the maximum tensile stress (UTS), elongation, and a diaphragm were measured 0.2%. In order to evaluate oxidation resistance, 850 ** and the high temperature oxidation test in the atmosphere of 1000 hours were done, and the mass increase of stock was measured. The result is shown in Table 3. The test result of Example 1 which uses as the main ingredients the Ni group collectively mentioned above is also shown.

[0079]

[Table 3]

	試料 No.	引張試験結果				酸化増量
		YS (MPa)	UTS (MPa)	伸び (%)	絞り (%)	(mg/cm^2)
実施例2	2(Co基)	345	420	30	48	4.1
比較例2	4(Co基)	280	301	25	28	4.5
実施例1	1(Ni基)	400	450	20	40	5.2

[0080]As shown in Table 3, having the 0.2% proof stress (YS) and the maximum tensile stress (UTS) in which the direction of Example 2 was excellent compared with the comparative example 2 was checked as a result of the elevated temperature tensile test. Although Example 2 which uses a Co group as the main ingredients was inferior in intensity compared with Example 2 which uses a Ni group as the main ingredients, excelling was checked about oxidation resistance. Therefore, when the alloy of Example 1 which uses a Ni group as the main ingredients with the product to apply when intensity is required, and oxidation resistance were required, it was checked that the alloy of Example 2 which uses a Co group as the main ingredients is effective.

[0081]Next, it was investigated whether about the alloy of Example 1 and the comparative example 1 which use a Ni group as the main ingredients, the heating test would be carried out in the temperature requirement (700 ** - 1000 **), and the embrittlement phase would have appeared in the specimen in-house after a heating test. The heating prescription test result of Example 1 and the comparative example 1 is shown in drawing 6 and drawing 7.

[0082]The test piece for tensile test was extracted from Example 1 and the comparative example 1 which carried out the heating test at 850 **, the elevated temperature tensile test (test temperature: 850 **) was carried out, and proof stress (YS) and elongation were measured 0.2%. The elevated temperature tensile test result is shown in Table 4 and drawing 8.

[0083]

[Table 4]

	試料 No.	未時効		50時間		100時間		1000時間		5000時間	
		YS (MPa)	伸び (%)	YS (MPa)	伸び (%)	YS (MPa)	伸び (%)	YS (MPa)	伸び (%)	YS (MPa)	伸び (%)
実施例1	1(Ni基)	400	20	399	20	398	19	382	18	360	16
比較例1	3(Ni基)	345	25	275	18	230	14	192	10	180	9

[0084]As shown in Table 4, drawing 6, and drawing 7, it was checked as a result of the heating test that the prescription time when an embrittlement phase appears compared with the comparative example 1 at every test temperature in the direction of Example 1 becomes late. Compared with the comparative example 1, it was checked as a result of the elevated temperature tensile test of drawing 8 that there are few the intensity and the

ductile falls accompanying heating prescription in the direction of Example 1. Therefore, it became clear that the alloy of Example 1 which uses a Ni group as the main ingredients had the outstanding structural stability.
[0085]Next, the microstructure about the flame tube 14 which shows drawing 1 manufactured by this embodiment was observed.
[0086]Drawing 9 is a figure showing the organization after the forging treatment looked at by the flame tube.
[0087]As shown in drawing 9, this organization has homogeneity and the crystal grain 18 which carried out minuteness making rather than the precision casting alloy structure which showed drawing 20 of the conventional example. $M_{23}C_6$ type carbide 19 and MC type carbide 20 which are deposit carbide are distributing more minutely than the precision casting alloy structure which showed drawing 20.
[0088]By performing forging treatment and manufacturing a flame tube from the above test result, according to this embodiment, Since dispersion in strong was lost as cast structure, such as a big and rough columnar crystal, was destroyed, and it was shown in drawing 2 and drawing 3, and a crystal grain equalized compared with the organization after a forge and it was shown in sample No.1 in Example 1 of drawing 4, it became clear that intensity improved substantially.
[0089]As a result of observing the microstructure of a flame-tube section which performed forging treatment, the crystal grain carried out minuteness making of the crystal grain 18 after the forge shown in drawing 9 rather than the crystal grain 9 after casting shown in drawing 20 of the conventional example, and it was checked that high temperature strength improves substantially as shown in Example 1 of drawing 4.
[0090]As a result of observing the microstructure of a flame-tube section similarly, $M_{23}C_6$ type carbide 19 and MC type carbide 20 which play the role of precipitation strengthening and which are carbide were carrying out fine dispersion. Especially $M_{23}C_6$ type carbide 19 changes to an embrittlement phase in connection with heating prescription, as shown in a conventional example. If it explains concretely, chemical composition will make Cr, Mo, and W the subject, and many $M_{23}C_6$ type carbide 6 to a grain boundary shown in drawing 20 will be seen. And as shown in drawing 21 of a conventional example, many embrittlement phases 8 which deposit are seen near the grain boundary, and can say this embrittlement phase 8 as that from which $M_{23}C_6$ type carbide 6 changed to the embrittlement phase 8 in connection with heating prescription. By performing forging treatment after casting and carrying out fine dispersion of the $M_{23}C_6$ type carbide 19 shown in drawing 9 from this, the segregation of Cr and Mo which are the generator matter of the embrittlement phase 8, and W decreases, and as shown in Example 1 of drawing 6, generation of an embrittlement phase is controlled. As a result, the flame tube 14 which excelled the conventional flame tube 4 made from a precision casting alloy in the structural stability in heating prescription can be provided.
[0091]According to this embodiment, by using a casting process, although excelled in heat resistance, processing to flame-tube shape becomes applicable [the difficult alloy], and even when it is complicated shape, the flame tube 14 can be manufactured easily.
[0092]In the 2nd embodiment (comparative-example; drawing 10 [an example, / -] drawing 11: Tables 5-6) book embodiment, it checked having the characteristic excellent in the flame tube which comprised a charge of an alloy in the chemical composition range of this invention which uses a Ni group as the main ingredients.

[0093]EXAMPLE (Table 5; sample No.7) -- in this example, the charge of an alloy which has a chemical entity which uses as the main ingredients the Ni group shown in sample No.7 of Table 5 was used.
[0094]
[Table 5]

	試料 No.	化学組成 (wt%)									
		Cr	Co	W	Al	Ti	Ta	Nb	C	Hf	Ni
実施例	7(Ni基)	22.5	19.0	2.0	1.9	1.0	1.0	0.8	0.1	0.15	bal.
比較例	8(Ni基)	26.2	18.2	3.5	1.7	1.0	1.3	1.1	0.1	0.15	bal.
	9(Ni基)	17.5	19.1	2.3	2.1	0.8	1.2	1.3	0.1	0.15	bal.
	10(Ni基)	23.1	23.7	2.9	1.5	0.8	1.1	1.2	0.2	0.15	bal.
	11(Ni基)	22.7	16.5	3.5	1.9	1.3	0.9	0.9	0.1	0.15	bal.
	12(Ni基)	22.4	19.3	10.5	2.3	1.1	1.0	1.5	0.2	0.15	bal.
	13(Ni基)	23.2	17.5	3.5	–	1.0	1.2	1.3	0.1	0.15	bal.
	14(Ni基)	22.6	20.1	2.5	3.0	1.2	1.2	1.1	0.2	0.15	bal.
	15(Ni基)	22.2	19.3	3.2	1.3	2.4	1.4	1.2	0.1	0.15	bal.
	16(Ni基)	22.5	19.2	4.6	2.3	1.2	2.4	1.0	0.1	0.15	bal.
	17(Ni基)	23.5	19.5	3.5	1.5	1.1	1.1	2.2	0.1	0.15	bal.
	18(Ni基)	22.3	20.2	4.1	2.1	1.3	1.2	0.9	0.6	0.15	bal.

[0095]Sample No.7 is weight % and Cr:18.0-25.0%, Co:17.0-23.0%, W and : [at least one sort of] 10.0% or less of Mo, and aluminum : 0.01 to 3.0%, Ti: Less than 2.0%, less than Ta:2.0%, less than Nb:2.0%, Hf : Are in 0.5% or less and C:0.5% or less of range, and specifically, By weight %, the remainder was used as nickel and inevitable impurities including Cr:22.5%, Co:19.0%, W:2.0%, aluminum:1.9%, Ti:1.0%, Ta:1.0%, Nb:0.8%, C:0.1%, and Hf:0.15%.
[0096]Forging treatment was performed, after casting in the charge of an alloy which has the above-mentioned presentation and obtaining a steel ingot. What performed solution treatment at 1150 ** after forging treatment for 4 hours, and performed aging treatment at 802 more ** for 8 hours was made into the sample board.
[0097]In the comparative example (Table 5; sample No.8-No.18) book comparative example, the charge of an alloy which has a chemical composition ingredient which uses as the main ingredients the Ni group shown in sample No.8 of Table 5 - No.18 was used.
[0098]Specifically, sample No.8 - No.18 contain ingredients other than the range.
[0099]Forging treatment was performed, after casting in the charge of an alloy which has the above-mentioned presentation and obtaining a steel ingot. What performed solution treatment at 1150 ** after forging treatment for 4 hours, and performed aging treatment at 802 more ** for 8 hours was made into the sample board.
[0100]Thus, in order to evaluate the sample board of the example and comparative example which were acquired, the elevated temperature tensile test (test temperature: 850 **) was done, and proof stress (YS), the maximum tensile stress (UTS), elongation, and a diaphragm were measured 0.2%. In order to evaluate oxidation resistance, 850 ** and the high temperature oxidation test in the atmosphere of 1000 hours were done, and the mass increase of stock was measured. In order to evaluate weldability, the bead one examination by TIG arc welding was carried out, and the existence of the crack of a weld zone was checked. These evaluation test results are shown in drawing 10, drawing 11, and Table 6.
[0101]
[Table 6]

	試料 No.	引張試験結果				酸化増量 (mg/cm^2)	溶接試験
		YS (MPa)	UTS (MPa)	伸び (%)	絞り (%)		
実施例	7(Ni基)	400	450	20	40	5.2	良好
比較例	8(Ni基)	355	401	27	51	8.4	良好
	9(Ni基)	372	422	10	19	5.3	良好
	10(Ni基)	304	352	38	62	5.5	良好
	11(Ni基)	362	412	24	48	8.2	良好
	12(Ni基)	379	429	11	18	1.7	割れ
	13(Ni基)	285	312	42	65	6.5	良好
	14(Ni基)	420	472	8	16	5.9	割れ
	15(Ni基)	426	475	9	21	5.9	割れ
	16(Ni基)	365	390	11	22	6.1	割れ
	17(Ni基)	371	403	22	38	8.2	良好
	18(Ni基)	381	410	10	15	6.2	良好

[0102]As shown in Table 6, drawing 10, and drawing 11, about Cr, oxidation resistance was falling by sample No.9 with high temperature strength low at sample No.8 with high content of Cr, and low content of Cr.
[0103]About Co, oxidation resistance was falling with the alloy of sample No.11 with high temperature strength low with the alloy of sample No.10 with high content of Co, and low content of Co.
[0104]About W, toughness was falling with the alloy of sample No.12 with high content of W.
[0105]About aluminum, weld cracking occurred with the alloy of sample No.14 with high temperature strength low at sample No.13 which aluminum does not contain, and high content of aluminum.
[0106]About Ti, weld cracking occurred also in sample No.15 with high content of Ti.
[0107]About Ta and Nb, oxidation resistance was falling by sample No.16 with high content and No.17 of Ta and Nb.
[0108]About C, toughness was falling by sample No.18 with high content of C.
[0109]According to this embodiment, compared with the alloy [in / in the alloy in sample No.7 of an example / sample No.8 of a comparative example - No.18], the value of 0.2% proof stress and the maximum tensile stress was high, and excelling in high temperature strength was checked. It became clear that it was satisfactory also in oxidation resistance and weldability.
[0110]In the 3rd embodiment (drawing 12 -13: Tables 7-8) book embodiment, it checked having the characteristic excellent in the flame tube which comprised a charge of an alloy which uses the Co group in the chemical composition range of this invention as the main ingredients.
[0111]EXAMPLE (Table 7; sample No.19) -- in this example, the charge of an alloy which has a chemical composition ingredient which uses as the main ingredients the Co group shown in sample No.19 of Table 7 was used.
[0112]
[Table 7]

	試料 No.	化 学 組 成 (wt%)						
		Cr	Ni	W	Ta	Ti	C	Co
実施例	19(Co基)	23.5	10.0	7.0	3.5	0.2	0.6	bal.
比較例	20(Co基)	36.5	10.2	6.8	3.3	0.3	0.5	bal.
	21(Co基)	14.7	9.9	6.8	3.2	0.2	0.6	bal.
	22(Co基)	23.2	32.0	8.1	3.1	0.3	0.6	bal.
	23(Co基)	23.1	4.2	7.4	3.1	0.3	0.5	bal.
	24(Co基)	23.6	10.2	20.4	3.4	0.4	0.6	bal.
	25(Co基)	23.5	10.1	6.8	5.8	0.3	0.6	bal.
	26(Co基)	24.9	10.1	7.4	3.2	2.7	0.6	bal.
	27(Co基)	23.0	9.8	7.2	3.2	0.2	1.3	bal.

[0113]As shown in Table 7, sample No.19 is weight % and Cr:15.0-35.0%, nickel: 5.0-30.0%, W:20.0% or less, less than Ta:5.0%, Ti : Are 2.0% or less and C:1.0% or less of range, and specifically, By weight %, the remainder was used as Co and inevitable impurities Cr:23.5%, nickel:10.0%, and W:7.0% including less than Ti:0.2%, less than Ta:3.5%, and C:0.6%.
[0114]Forging treatment was performed, after casting in the charge of an alloy which has the above-mentioned presentation and obtaining a steel ingot. What performed solution treatment at 1175 ** for 1 hour was made into the sample board after forging treatment.
[0115]In the comparative example (Table 7; sample No.20-No.27) book comparative example, the charge of an alloy which has a chemical entity which uses as the main ingredients the Co group shown in sample No.20 of Table 7 - No.27 was used.
[0116]Specifically, sample No.20 - No.27 contain ingredients other than the chemical composition range of this invention.
[0117]Forging treatment was performed, after casting in the charge of an alloy which has the above-mentioned presentation and obtaining a steel ingot. What performed solution treatment at 1175 ** for 1 hour was made into the sample board after forging treatment.
[0118]Thus, in order to evaluate the sample board of the example and comparative example which were acquired, the elevated temperature tensile test (test temperature: 850 **) was done, and proof stress (YS), the maximum tensile stress (UTS), elongation, and a diaphragm were measured 0.2%. In order to evaluate oxidation resistance, 850 ** and the high temperature oxidation test in the atmosphere of 1000 hours were done, and the mass increase of stock was measured. In order to evaluate weldability, the bead one examination by TIG arc welding was carried out, and the existence of the crack of a weld zone was checked. These evaluation test results are shown in drawing 12, drawing 13, and Table 8.
[0119]
[Table 8]

	試料 No.	引張試験結果				酸化増量 (mg/cm^2)	溶接試験
		YS (MPa)	UTS (MPa)	伸び (%)	絞り (%)		
実施例	19(Co基)	345	420	30	48	4.1	良好
比較例	20(Co基)	300	376	36	47	7.2	良好
	21(Co基)	304	381	13	24	5.1	良好
	22(Co基)	275	332	25	43	6.9	良好
	23(Co基)	245	304	28	46	4.7	良好
	24(Co基)	365	435	8	15	4.8	割れ
	25(Co基)	335	408	16	27	4.9	割れ
	26(Co基)	325	401	18	28	5.1	割れ
	27(Co基)	330	411	8	15	4.6	良好

[0120]As shown in Table 8, drawing 12, and drawing 13, about Cr, oxidation resistance was falling with the alloy of No.21 with high temperature strength low with the alloy of sample No.20 with high content of Cr, and low content of Cr.
[0121]About nickel, oxidation resistance was falling with the alloy of sample No.23 with high temperature strength low at sample No.22 with high content of nickel, and low content of nickel.
[0122]About W, toughness was falling with the alloy of sample No.24 with high content.
[0123]About Ta and Ti, weld cracking occurred with the alloy of sample No.25 with high content, and sample No.26.
[0124]About C, toughness was falling by sample No.27 with high content.

[0125]According to [above result] this embodiment, compared with the alloy of a comparative example, the value of 0.2% proof stress and the maximum tensile stress was high, and, as for the alloy which uses as the main ingredients the Co group shown in sample No.19 of an example, excelling in high temperature strength was checked. Although high temperature strength was a little inferior compared with the alloy which uses a Ni group as the main ingredients, it became clear that it excelled dramatically in oxidation resistance.
[0126]In the 4th embodiment (drawing 14 -16) book embodiment, by using a centrifugal casting process as a casting process explains that the flame tube which has the outstanding intensity can be manufactured.
[0127]Drawing 14 is a figure showing the manufacturing process of a flame tube.
[0128]As shown in drawing 14, the flame-tube-shaped cast 23 is first produced like drawing 14 (b) like drawing 14 (a) using the flume circumstantiality heart casting process which pours in and casts the molten metal 22 (a Ni group or a Co group) to the rotating bell-shaped mold 21. Like drawing 14 (c), by carrying out forging treatment, the cast structure generated in the casting stage is destroyed, and the forging 24 without cast structure is produced to this cast 23. Then, finishing by machining is performed like drawing 14 (d), and it is considered as the flame tube 25.
[0129]Thus, in order to verify the characteristic of the obtained flame-tube material, the specimen of the example and comparative example which are shown below was produced, and the verification test was done.
[0130]EXAMPLE (Table 1; sample No.1) -- in this example, it has the chemical composition range of sample No.1 shown in Table 1, and the charge of an alloy which uses nickel as the main ingredients was used. What performed solution treatment at 1150 ** for 4 hours, and carried out aging treatment at 802 more ** for 8 hours about the casting alloy which produced this charge of an alloy with the centrifugal casting process after performing forging treatment was used as the specimen.
[0131]In comparative example (Table 1; sample No.1) this example, it has the chemical composition range of sample No.1 shown in Table 1, and the charge of an alloy which uses nickel as the main ingredients was used. What performed solution treatment at 1150 ** for 4 hours, and carried out aging treatment at 802 more ** for 8 hours about the casting alloy which usually produced this charge of an alloy according to the casting process after performing forging treatment was used as the specimen.
[0132]Thus, to each obtained specimen, the heating test was carried out in the temperature requirement (700 ** - 1000 **), and the embrittlement phase examined the existence of the appearance to the specimen in-house after a heating test. This heating test result is shown in drawing 15 and drawing 16.
[0133]As shown in drawing 15 and drawing 16, it was checked as a result of the heating test that the prescription time when an embrittlement phase appears compared with a comparative example in the direction of an example becomes late. It became clear that it had the structural stability excellent in the alloy in the example using a centrifugal casting process from this.
[0134]According to this embodiment, by using a centrifugal casting process, a cast with comparatively few alloy segregations can be produced, effects, such as improving strength by subsequent forging treatment, become large, and the further outstanding flame tube can be obtained.

[0135]In the 5th embodiment (drawing 17) book embodiment, how to manufacture a flame tube using extrusion as plastic working between heat is explained.
[0136]Drawing 17 is a figure showing the manufacturing process of a flame tube.
[0137]As shown in drawing 17 (a), first, the molten metal 27 (a Ni group or a Co group) is cast to the cylindrical mold 26 using a casting process, and as shown in drawing 17 (b), the flame-tube-shaped cast 28 is produced. While processing ingot articles tubular with extrusion to the cast 28, the cast structure generated in the casting stage is destroyed, and as shown in drawing 17 (c), the forging 29 without cast structure is produced. Then, as shown in drawing 17 (d), finishing by machining is performed and it is considered as the flame tube 30.
[0138]According to this embodiment, since a hollow type mold is not needed and the cylinder mold which is simple shape can be applied, the manufacturing cost of a mold is mitigable.
[0139]In the 6th embodiment (drawing 18) book embodiment, how to perform forging treatment accompanied by expansion as plastic working between heat, and to manufacture a flame tube is explained.
[0140]Drawing 18 is a figure showing the manufacturing process of a flame tube.
[0141]As shown in drawing 18 (a), the molten metal 32 (a Ni group or a Co group) is first cast using a casting process to the hollow cylinder mold 31 smaller than the actual diameter of a liner, and as shown in drawing 18 (b), the flame-tube-shaped cast 33 is produced. To the cast 33, as shown in drawing 18 (c), the forging 34 without cast structure is produced by performing forging treatment accompanied by expansion destroying the cast structure generated in ingot articles, and by performing pipe expanding of ingot articles simultaneously. Then, as shown in drawing 18 (d), finishing by machining is performed and it is considered as the flame tube 35.
[0142]According to this embodiment, since the mold 31 is small and ends, the manufacturing cost of a mold is mitigable.
[0143]
[Effect of the Invention]As explained above, according to a flame tube for gas turbines of this invention, and a manufacturing method for the same, after performing casting processing, the flame tube which is excellent in high temperature strength, and the organization change accompanying heating prescription does not produce easily can be obtained by performing plastic working between heat.

[Translation done.]